AD

TECHNICAL REPORT

72-76-FL

THE EFFECT OF HIGH TEMPERATURE STORAGE ON THE ACCEPTABILITY AND STABILITY OF INTERMEDIATE MOISTURE FOOD

by

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May 1972

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory

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FOREWORD

The need for a combat ration offering a balanced diet, high palatability, minimum weight and bulk, no preparation for use, and an outstanding degree of safety even in the event of package failure, has long been recognized by the Armed Forces.

The meat component of existing types of combat rations, Meal, Combat, Individual, and the Freeze Dried Long Range Patrol Food Packet, are both deficient in at least one of the above mentioned requirements. We feel intermediate moisture foods can be developed to meet all of the above requirements, thus allowing the soldier added flexibility and increased efficiency.

The inventory of currently available intermediate moisture foods such as dried fruits, dry sausages, and confectionery products, have only limited military application. Commercial development of new intermediate moisture items has been mainly confined to pet foods and contracts let by the U.S. Army Natick Laboratories, Natick, Massachusetts. To date, low sensory values and lack of storage data have hindered the entry of intermediate moisture foods into the military feeding systems.

Four intermediate moisture food items, having favorable panel ratings, have been developed at the U.S. Army Natick Laboratories, with basic sensory properties considered satisfactory for a meat component of a combat ration. This report describes the development and formulation of these items, and the effect of high temperature storage on their acceptability and stability.

This work was performed under Project 1J662713D553, Military Food Service and Subsistence Technology.

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ABSTRACT

Four intermediate moisture meat entree items (A_w 0.81 - 0.86) developed at the U.S. Army Natick Laboratories, Natick, Massachusetts, were held in storage for a period of six months at 38°C. The products studied were, intermediate moisture pork with barbecue sauce, pork with sweet and sour sauce, pork with oriental sauce, and ham with sweet mustard sauce..

Microbiological, nutritional, and sensory evaluations were conducted on these products at pre-determined storage intervals.

Taste panel evaluation indicated that pork with barbecue sauce maintained its sensory properties for three months at 38°C., without any significant change, while ham with sweet mustard sauce and pork with oriental sauce had no loss in panel acceptability over the six month period. Pork with sweet and sour sauce showed a significant decrease in panel acceptability between the zero and three month storage periods.

Vitamin and chemical data indicate that these intermediate moisture foods are comparable to existing combat ration meat components in nutrient content, and that vitamin retention during storage is similar to those of foods processed by commercial methods.

Microbiological data indicated that all products tested were microbially stable.

INTRODUCTION

The term, "intermediate moisture," has recently been applied to a heterogeneous group of commercial foods which contain 20 to 40% moisture but do not require refrigeration for stability even though viable microorganisms and spores may be present. Several members of this group include, marshmallows, jams, certain bakery products, and meat items such as pepperoni and other dry sausages. All products can be eaten from the intermediate moisture state without further preparation.

Water is essential for the growth of microorganisms and for the germination of spores. Within a microenvironment, the availability of water for growth and other vital functions is determined by its relative vapor pressure or water activity, rather than by its concentration. Water activity (A_w) is defined as the ratio of water vapor pressure (P) of the system to the vapor pressure of pure water (P_o) at the same temperature, $A_w = \frac{P}{P_o}$. Likewise, when the water within a system is in equilibrium with its vapor, the relative humidity (RH) of the system, expressed in percent, bears a simple relationship to water activity, $A_w = \frac{RH}{100}$. Since the response of P and P_o to temperature are nearly proportional, A_w is only slightly influenced by temperature over the growth range characteristics of mesophilic microorganisms.

The microbiological stability of intermediate moisture foods results from an interruption of vital processes essential to microbial growth or spore germination which is mediated by a depressed availability or activity of water in the food. Every microorganism has an optimum and a minimum water activity for growth. A reduction below optimum delays spore germination, lengthens the log phase, and decreases the growth rate. The effect of water activity on microbial growth is influenced by other factors affecting growth, such as temperature, nutrients, and other components of the medium, such as pH, and oxygen supply. The minimum water activity which will permit growth or spore germination is determined with all other factors optimal. From data presented by Ayers (1965), Christian (1963), Denny et al. (1969), Elliott and Michener (1965), Frazier (1967), Hansen and Riemann (1962), Mossell and Ingram (1955), and Scott (1957), it can be concluded that the water activity necessary for inhibition would be approximately 0.01 unit lower than the minimum water activity for microbial growth and spore germination (Brockmann, 1971).

The above investigators also indicate that spores cannot germinate and relatively few species of bacteria, including only one food pathogen, can multiply at $A_w = 0.90$. Under favorable conditions Staph. aureus has been observed to grow at A_w as low as 0.86. Halophilic bacteria may grow at A_w as low as 0.75, which corresponds to a saturated solution of sodium chloride. The common species of yeast and mold are suppressed at $A_w = 0.88$ and 0.80, respectively, while the limits for xerophilic molds and osmophilic yeast are estimated to be 0.65 and 0.60 respectively.

Numerous methods for determination of water activity have been reviewed by Gal (1967), Stitt (1958), and Landrock and Proctor (1951). Currently electric hygrometers are widely used for identifying the relative humidity in equilibrium with food.

Commercial development of intermediate moisture foods has been proven feasible with the advent of low moisture pet food in the commercial market. By incorporating an effective antimycotic agent, heating to destroy vegetative organisms, adjusting to A_w of approximately 0.85, and sealing in inexpensive plastic pouches, these pet foods have had an excellent record for stability under market conditions (Brockmann, 1970).

Pilot studies conducted by General Food Corporation for the U.S. Army Natick Laboratories, have shown that intermediate moisture casserole items (A_w = 0.85) inoculated with Staph. aureus (12,000 - 14,000 organisms per g) were practically free (0.4 organisms per g) after a storage period of four months at 38°C. (Hollis et al., 1969).

Present meat components of combat rations available to the combat soldier are in two forms; the Meal, Combat, Individual or canned type component, which has a moisture content in the neighborhood of 75%, and the freeze dried Long Range Patrol Food Packet, which contains less than 10% moisture. Canned type components are generally favorably received by the combat soldier, apparently because he is familiar with this type item. However, the elevated moisture content of such products necessitates thermal processing in sealed rigid containers to obtain a commercially sterile product, thereby adding to the weight and bulk of a soldier's load. Furthermore, once a can is opened, it must be quickly consumed since the product is quite conducive to supporting microbial growth and hence will deteriorate rapidly unless refrigerated.

Freeze dried meat components have a high nutritional and caloric value. They are also relatively light, and have excellent storage characteristics when protected from moisture and oxygen in flexible packages. However, many freeze dried products are not acceptable when consumed dry. Rehydration restores palatability but requires time, a diversion of attention, and preferably hot water, or at least an ample supply of water. Therefore, the desirable characteristics of high nutritional value, and resistance to microbial spoilage are defeated by the low palatability in the dry state, or circumstances unfavorable to reconstitution.

Intermediate moisture foods, on the other hand, offer concentration from the standpoint of weight, bulk, and caloric content. They are suitable for direct consumption with no preparation, are inexpensively packaged, and provide safety from microbial spoilage in case of package failure.

Since only limited storage data are available for intermediate moisture foods, this study was undertaken to determine the effect of high temperature storage on acceptability and stability of four intermediate moisture entree items developed in the course of this investigation.

EXPERIMENTAL PROCEDURE

Four intermediate moisture meat entree items in intermediate moisture sauces were prepared. The intermediate moisture products used in this study were, pork with sweet and sour sauce, pork with barbecue sauce, pork with oriental sauce, and ham with sweet mustard sauce. Preparation methods and formulas for both meat and sauces are presented in the following pages.

INTERMEDIATE MOISTURE MEAT PREPARATION

Intermediate moisture meat was prepared by immersing and cooking lean meat chunks in an aqueous glycerol solution of such predetermined composition that after equilibration with the aqueous phase of the meat, it would contain the desired water activity (0.80-0.85) and concentrations of antimycotic.

Intermediate Moisture Pork

Boneless pork loins (approximately 10 lbs. per loin) were obtained from a local meat wholesaler. The longissimus dorsi muscle was excised from each loin and all visible fat and connective tissue removed. The longissimus dorsi muscle was then diced into 1.5 x 1.5 x 1.5 cm chunks. All meat was held in covered stainless steel pots at 4°C. until the time for cooking and equilibration.

A pork equilibration solution was prepared consisting of an aqueous solution of glycerol, water, salt, soup and gravy base, and antimycotic.

Cook-Soak Equilibration Solution Formula for Intermediate Moisture Pork

% By Weight	Ingredient
53.00	Glycerol (Fisher, USP)
39.70	Water
5.00	Salt
2.00	Chicken Soup and Gravy Base
0.30	Potassium Sorbate
100.00	Total

Pork chunks and equilibration solution were combined in a large steam kettle in the ratio of 1:1.5. The pork was cooked in the equilibration solution for 15 minutes at 77°C. Heat was removed from the steam kettle, and the pork allowed to equilibrate in the equilibration solution for 16 hours at 22°C. The low water activity of the equilibration solution prevented growth of microorganisms during the equilibration period. At the end of the equilibration period, the equilibration solution was drained, pork chunks spread onto flat drying pans and air dried until surface moisture evaporated. Random samples for water activity determination were taken at this point. The procedure used for water activity determination was the same

as described by Landrock and Proctor (1951). The equilibrated pork was then stored in covered stainless steel pots at 4°C. until combination with its respective intermediate moisture sauce and packaging. Pork chunks for all three pork products were prepared in the manner described above.

Intermediate Moisture Ham

Boneless, rolled, smoked hams (approximately 10 lbs. per ham) were obtained from a local meat wholesaler. The ham was sliced into 0.5 cm slices on a US Bekel Slicer Model No. 807. a/ The ham slices were then trimmed of all visible fat and connective tissue, and cut into 2 x 2 cm pieces, thus giving 0.5 x 2 x 2 cm lean ham pieces. The ham chunks were held in covered stainless containers at 4°C. until time for cooking and equilibration. The ham equilibration solution formula is given below:

Cook-Soak Equilibration Solution Formula for Intermediate Moisture Ham

% By Weight	Ingredient
53.00	Glycerol (Fisher USP)
41.00	Water
5.00	Salt
0.30	Potassium Sorbate
100.00	Total

Cooking and equilibration procedures for the ham were the same as previously described for the intermediate moisture pork.

INTERMEDIATE MOISTURE SAUCE PREPARATION

Intermediate moisture sauces were prepared by combining conventional sauce ingredients with predetermined amounts of glycerol as to give a completed sauce with the desired water activity (0.80-0.85). Through trial and error, sauce ingredients were adjusted so as to mask the extreme sweetness and bitter after-taste of the glycerol in the sauce. Also, sauces with naturally sweet flavors were selected so as to mask the sweetness of the meats due to their glycerol content. No antimycotic was incorporated in sauce formulas, since it was thought that sauce ingredients, catsup, tomato paste, etc., contained adequate amounts of sugar and soluble solids to inhibit yeast and mold growth.

a/ The U.S. Slicing Machine Company Inc., La Porte, Indiana.

Intermediate Moisture Sweet and Sour Sauce

Composition of Intermediate Moisture Sweet and Sour Sauce for Pork

% By Weight	Ingredient
27.00	Glycerol (Fisher, USP)
15.00	Vinegar (cider)
35.00	Tomato Catsup
5.00	Orange Marmalade
2.00	Onion Flakes (dried)
2.00	Pineapple Chunks (freeze dried)
4.00	Lemon Juice
0.07	Ginger (ground)
0.50	Salt
0.03	Black Pepper
1.00	Worcestershire Sauce
5.40	Water
3.00	Starch (Col-Flo 67)
100.00	Total

All ingredients, excluding starch and water, were combined in a double boiler and cooked slowly for 30 minutes. The starch-water mixture was then included, and the sauce constantly stirred until thickening occurred. The completed sauce was allowed to cool to room temperature (22° C. 50% RH), and then vacuum sealed in No. 10 cans under 25 inches Hg, and stored at 4°C. until packaging.

Intermediate Moisture Oriental Sauce

Composition of Intermediate Moisture Oriental Sauce for Pork

% By Weight	Ingredient
25.00	Glycerol (Fisher, USP)
10.00	Vinegar (cider)
15.00	Pineapple Juice
1.00	Worcestershire Sauce
4.00	Soy Sauce
7.00	Green Bell Peppers (fresh-chopped)
5.00	Celery (fresh-chopped)
3.00	Pineapple chunks (freeze-dried)
2.00	Onion Flakes (dried)
0.03	Ginger (ground)
5.00	Soup and Gravy Base (chicken)
7.00	Salt
10.97	Water
5.00	Starch (Col-Flo 67)
100.00	Total

Celery, green peppers, onion flakes, pineapple chunks, water, and vinegar were combined in a double boiler and brought to a boil. Remaining ingredients, excluding starch and pineapple juice, were added and the total contents were cooked under low heat for five minutes. The starch-pineapple juice mixture was then included and sauce was stirred constantly until thickening occurred. The completed sauce was allowed to cool to room temperature (22°C., 50% RH) and vacuum sealed in No. 10 cans under 25 inches Hg. The completed sauce was then stored at 4°C. until packaging.

Intermediate Moisture Barbecue Sauce

Composition of Intermediate Moisture Sauce for Pork

% By Weight	Ingredients
25.00	Glycerol (Fisher, USP)
35.00	Tomato Paste (26% solids)
1.00	Tabasco Hot Sauce
1.00	Worcestershire Sauce
17.00	Vinegar (cider)
5.00	Onion Flakes (dried)
1.00	Salt
6.00	Soup and Gravy Base (beef)
0.02	Ginger (ground)
3.00	Starch (Col Flo 67)
5.98	Water
100.00	Total

All ingredients, excluding the starch and one-half the water volume, were cooked slowly in a double-boiler for 30 minutes. The starch-water mixture was then included and constantly stirred until sauce thickening occurred. The sauce was allowed to cool to room temperature (22°C., 50% RH), vacuum sealed in No. 10 cans under 25 inches Hg, and stored at 4°C. until packaging.

Intermediate Moisture Sweet Mustard Sauce.

Composition of Sweet Moisture Mustard Sauce

% By Weight	Ingredient
30.00	Glycerol (Fisher, USP)
50.00	Prepared Mustard
10.00	Vinegar (cider)
4.00	Brown Sugar (light)
1.00	Salt
5.00	Starch (Col-Flo 67)
100.00	Total

All ingredients, excluding starch and vinegar, were combined in a double-boiler and brought to a slow boil. The starch-vinegar mixture was then added and constantly stirred until thickening occurred. The sauce was allowed to cool to room temperature (22°C. 50% RH), vacuum sealed in a No. 10 can under 25 inches Hg, and stored at 4°C. until packaging.

FINAL PRODUCT PREPARATION, PACKING AND STORAGE

Prior to a sauce-meat combination each sauce was mixed in a Hobart Mixer Model No. S260 a/ for five minutes, and three random samples for water activity determination were taken at this point. Procedures for determination of water activity were the same as described by Landrock and Proctor (1951).

Meat chunks were combined with their respective sauces in the ratio of 1.67 to one. 160 g of combined product were vacuum sealed under 29 inches Hg in 19 x 11 cm, 3-ply laminated flexible packages (inner ply = 0.003 inch polyolefin, middle ply = 0.00035 inch aluminum foil and outer ply = 0.0005 polyester mylar) on a Flex-Vac Vacuum Sealer, Model No. 65. b/

Samples of each product were taken at this time for initial analysis. The remaining samples of each product were placed in 12 x 16 x 9 inch boxes and stored at 38°C.

Initial Water Activity Values of Intermediate Moisture Meats, Sauces and Combined Products Stored at 38°C.

Intermediate Moisture Items	Observed Initial A_w c
Pork	0.82
Barbecue Sauce	0.89
Pork with Barbecue Sauce	0.86
Pork	0.81
Sweet and Sour Sauce	0.83
Pork With Sweet and Sour Sauce	0.84
Pork	0.80
Oriental Sauce	0.84
Pork With Oriental Sauce	0.85
Ham	0.79
Mustard Sauce	0.83
Ham With Mustard Sauce	0.81

a/ The Hobart Manufacturing Company, Troy, Ohio.
b/ Standard Packaging Corporation, New York, New York.
c/ The method used for water activity determination was described by Landrock and Proctor, (1951).

MICROBIOLOGICAL, NUTRITIONAL, CHEMICAL AND ACCEPTABILITY ANALYSES

Microbiological Analysis

Microbiological examination for aerobes, anaerobes, aerobic spore formers, anaerobic spore formers, yeasts and molds were conducted on three initial random samples and on three random samples of each product stored at 38°C. at intervals for six months.

Nutritional Analysis

Vitamin Analysis:

Thiamine, riboflavin, niacin, and pyridoxine levels of each product were determined on five random samples of each product at zero, three, and six months of storage at 38°C.

Chemical Analysis:

Chemical analyses consisting of moisture, protein, fat, fiber, ash, phosphorous, sodium, potassium, calcium, magnesium, chloride and iron were conducted on five random initial samples of each item.

Determination of Product Acceptability

Acceptance taste panels were conducted on random samples of all four products at zero, three and six months storage periods. Products were rated on a 1 (dislike extremely) to 9 (like extremely) Hedonic Scale (Peryam and Pilgrim, 1957). Twenty-nine untrained panelists were used at each testing period. Panelists were separated by dividers while testing and given water to rinse their mouths between each sample.

Statistical Analysis

A completely randomized design was used to test panel acceptability ratings. Comparison between storage periods were determined by using an Analysis of Variance and F Test. Duncan's New Multiple Range Test was used to determine the significance between means within a treatment (Steel and Torrie, 1960).

RESULTS AND DISCUSSIONS

Gross Examination

Three month samples of pork products, stored at 38°C. developed a slightly reddish-brown color to the pork. The pork and ham in six months samples were very brown, giving all products a poor appearance. All sauces maintained a good characteristic color and appearance throughout the storage period. No fat oxidation was detected. This finding is in agreement with the observations of Loncin et al., (1968), who found that foods in the intermediate moisture range were less susceptible to fat oxidation than dry foods.

Microbiological Stability

From the data in Tables I, II, III and IV, it can be concluded that all four intermediate moisture food items were resistant to the growth of bacteria, yeast and mold. It should be noted that in all products the bacterial counts of aerobic, anarobic, aerobic spore formers, and anaerobic spore formers fluctuated from month to month, but bacterial counts never reached troublesome levels. All products were completely resistant to mold growth, and yeast were detected only at the two month storage time in all products. Possible explanations for the yeast counts only at two months are; two months were required for yeast to develop to a stage in which they could be detected in the laboratory, and after two months ceased to grow due to the production of growth inhibiting substances; and contamination in the microbiological laboratory at the time of the two month examinations.

TABLE I

MICROORGANISM COUNTS[a] ON INTERMEDIATE MOISTURE PORK WITH BARBECUE SAUCE IN STORAGE AT 38°C.

Storage Time (months)	Microorganism					
	Aerobic TPC/g	Anaerobic TPC/g	Aerobic spore formers per 2 g	Anaerobic spore formers per 2 g	Yeast per g.	Mold per g
0	120	130	+	+	< 10	< 10
1	11	61	+	+	< 10	< 10
2	< 10	27	+	+	215	< 10
3	135	125	+	+	< 10	< 10
4	< 10	40	+	+	< 10	< 10
5	15	45	+	+	< 10	< 10
6	190	137	+	+	< 10	< 10

[a] All analyses conducted in triplicate on a composite of three random samples.

TABLE II

MICROORGANISM[a] COUNTS ON INTERMEDIATE MOISTURE PORK WITH SWEET AND SOUR SAUCE IN STORAGE AT 38°C.

Storage Time (months)	Microorganism					
	Aerobic TPC/g	Anaerobic TPC/g	Aerobic spore formers per 2 g	Anaerobic spore formers per 2 g	Yeast per g	Mold per g
0	<10	<10	-	-	<10	<10
1	367	<10	-	-	<10	<10
2	108	<10	-	-	457	<10
3	135	125	+	+	<10	<10
4	<10	<10	-	-	<10	<10
5	<10	<10	-	-	<10	<10
6	<10	<10	-	-	<10	<10

[a] All analyses conducted in triplicate on a composite of three random samples.

TABLE III

MICROORGANISM COUNTS[a] ON INTERMEDIATE MOISTURE PORK WITH ORIENTAL SAUCE IN STORAGE AT 38°C.

Storage Time (months)	Microorganism					
	Aerobic TPC/g	Anaerobic TPC/g	Aerobic spore formers per 2 g	Anaerobic spore formers per 2 g	Yeast per g	Mold per g
0	15	30	+	+	<10	<10
1	13	<10	+	+	<10	<10
2	<10	<10	+	+	1833	<10
3	25	<10	-	-	<10	<10
4	<10	<10	+	+	<10	<10
5	<10	<10	-	-	<10	<10
6	17	<10	+	-	<10	<10

[a] All analyses conducted in triplicate on a composite of three random samples.

TABLE IV

MICROORGANISM COUNTS[a] ON INTERMEDIATE MOISTURE HAM WITH SWEET MUSTARD SAUCE IN STORAGE AT 38°C.

Storage Time (months)	Microorganism: Aerobic TPC/g	Anaerobic TPC/g	Aerobic spore former per 2 g	Anaerobic spore former per 2 g	Yeast per g	Mold per g
0	<10	<10	-	-	<10	<10
1	<10	<10	-	-	<10	<10
2	<10	<10	-	-	1600	<10
3	135	125	+	+	<10	<10
4	<10	<10	-	-	<10	<10
5	<10	<10	-	-	<10	<10
6	<10	<10	-	-	<10	<10

[a] All analyses conducted in triplicate on a composite of three random samples.

Nutritional Stability

For a comparison with initial nutritional data of a currently used combat ration meat component, see Table VII. Initial chemical data of all intermediate moisture products are presented in Table V. It should be noted that all intermediate moisture items were comparable in chemical nutrient content to existing combat ration meat components.

Vitamin analyses of the four intermediate moisture foods at zero, three and six months storage at 38°C. are given in Table VI. Harris (1960) has reported that frozen pork has a 40.0% thiamine loss after six months, canned pork a 48.0% thiamine loss after 43 weeks at 27-39°C., and a complete thiamine loss at 10 weeks for heat denatured pork. Some losses in thiamine were discovered in all intermediate moisture products except ham with sweet mustard sauce. All items showed a decrease in pyridoxine during the six month storage period, while little or no loss of riboflavin and niacin were noted.

TABLE V

INITIAL CHEMICAL ANALYSES[a] OF FOUR INTERMEDIATE MOISTURE FOOD ITEMS STORED AT 38°C. FOR SIX MONTHS

Analysis[b]	Intermediate Moisture Food Item			
	Ham/Mustard	Pork/Oriental	Pork/S&S	Pork/BBQ
Moisture (%)	43.10	45.90	43.80	45.50
Protein (%)	16.60	19.30	19.80	18.40
Fat (%)	1.09	4.18	4.57	4.02
Ash (%)	3.95	3.19	2.94	3.18
Fiber (%)	-----	0.70	0.30	3.30
Sodium (mg/100 g)	1335.00	1010.00	1320.00	1310.00
Potassium (mg/100 g)	118.00	148.00	197.00	223.00
Phosphorous (mg/100 g)	104.00	92.00	106.00	120.00
Calcium (mg/100 g)	29.00	18.00	22.00	20.00
Magnesium (mg/100 g)	21.00	13.00	14.00	20.00
Iron (mg/100 g)	1.30	0.84	1.06	1.47
Chloride as NaCl (%)	3.49	2.62	2.52	2.47

[a] Analyses were conducted by Shankmann Laboratories, 2023 S. Sante Fe Avenue, Los Angeles, California, using the following methods of analyses:

Moisture	A.O.A.C.	13.004	Ash	A.O.A.C.	13.006
Protein	A.O.A.C.	2.044	Phosphorous	A.O.A.C.	22.074
Fat	A.O.A.C.	22.033	Iron	A.O.A.C.	13.011
Fiber	A.O.A.C.	22.038	Chloride	A.O.A.C.	18.009
			Calcium	- Atomic Absorption Spectrophotometry	
			Sodium	" "	"
			Potassium	" "	"
			Magnesium	" "	"

[b] All analyses conducted in duplicate on a composite of five random samples.

TABLE VI

VITAMIN ANALYSES[a] OF FOUR INTERMEDIATE MOISTURE FOOD ITEMS AT ZERO, THREE AND SIX MONTHS IN STORAGE AT 38°C.

	Intermediate Moisture Food Items											
	Ham/Mustard			Pork/Oriental			Pork/S&S			Pork/BBQ		
	Storage Time (months)											
Analysis[b]	0	3	6	0	3	6	0	3	6	0	3	6
	(mg/100g)											
Thiamine[b]	0.067	0.120	0.060	0.250	0.180	0.078	0.250	0.180	0.240	0.260	0.160	0.069
% Change	--	+79.0	-1.0	--	-28.8	--	--	-28.8	-18.4	--	-38.5	-73.5
Riboflavin	0.101	0.100	0.115	0.069	0.080	0.114	0.090	0.090	0.109	0.247	0.110	0.136
% Change	--	-1.0	+13.9	--	+15.9	+65.2	--	0.0	+21.1	--	-25.2	-7.5
Niacin	1.570	1.540	1.630	1.540	1.420	1.520	2.320	2.180	2.220	2.480	2.300	2.510
% Change	--	-1.9	+3.2	--	-7.8	-1.3	--	-6.0	-4.3	--	-7.3	+1.2
Pyridoxine	0.055	0.042	0.031	0.063	0.052	0.0370	.059	0.061	0.043	0.110	0.098	0.080
% Change	--	-23.6	-43.4	--	-17.5	-41.3	--	+3.4	-27.1	--	-10.9	-27.3

[a] Analyses were conducted by Shankmann Laboratories, 2023 S. Sante Fe Avenue, Los Angeles, California, using the following methods of analyses:

Method of Vitamin Assay. 1966. Third Edition., Association of Vitamin Chemists, Interscience Publishers.

Thiamine	pp. 127-140
Riboflavin	pp. 158-164
Niacin	pp. 172-176
Pyridoxine	pp. 212-219

[b] All analyses conducted in duplicate on a composite of five random samples.

TABLE VII

INITIAL NUTRITION ANALYSES[a] OF A CURRENTLY USED ARMED FORCES COMBAT MEAT ENTREE ITEM

Pork, Canned, Sliced Cooked With Juices

Nutrient	Level
Moisture (%)	63.70
Protein (%)	21.20
Fat (%)	11.02
Ash (%)	3.72
Fiber (%)	0.08
Sodium (mg/100 g)	1049.00
Potassium (mg/100 g)	224.00
Phosphorous (mg/100 g)	159.00
Calcium (mg/100 g)	5.80
Magnesium (mg/100 g)	17.70
Iron (mg/100 g)	1.85
Chloride as NaCl (%)	2.76
Thiamine (mg/100 g)	0.205
Riboflavin (mg/100 g)	0.200
Niacin (mg/100 g)	2.360
Pyridoxine (mg/100 g)	0.219

[a]Analyses were conducted by Shankmann Laboratories, 2023 S. Sante Fe Avenue, Los Angeles, California, using the methods described for the intermediate moisture foods.

Product Acceptability

The mean, standard error, and F values for panel acceptability values of the four products at the zero, three and six month storage periods are presented in Table VIII.

A highly significant difference ($P<.01$) was found in taste panel acceptability values between the zero and six month storage periods of intermediate moisture pork with barbecue sauce. The acceptability values at the zero time storage ($\bar{X} = 6.28$), and the six month period ($\bar{X} = 5.17$) were found to be significantly different ($P<.01$). No significant difference was found between the zero and three month periods, and three and six month periods. These data, plus gross examination evaluation, suggests that the intermediate moisture pork with barbecue sauce may be stored at high temperatures for at least three months without any significant loss in product palatability. It appears that in storage over three months the product begins to lose its palatability. Reduction in palatability through meat browning and burned meat flavor is most probably due to the Maillard Reaction. Loncin et al., (1968),

TABLE VIII

TASTE PANEL ACCEPTABILITY RATINGS AND F VALUES OF FOUR INTERMEDIATE MOISTURE FOODS IN STORAGE FOR SIX MONTHS AT 38°C

Product	Statistic	Storage Period (months) 0	3	6	F Value
Pork with Barbecue Sauce	$\bar{X}$[a]	6.28	5.55	5.17	4.545**
	S.E.	b0.26	0.26	0.26	
Pork with Sweet and Sour Sauce	$\bar{X}$[a]	6.38	4.93	5.14	8.516**
	S.E.	b0.27	0.27	0.27	
Pork with Oriental Sauce	$\bar{X}$[a]	6.21	5.86	5.48	1.744[ns]
	S.E.	b0.28	0.28	0.28	
Ham with Sweet Mustard Sauce	$\bar{X}$[a]	5.86	5.52	5.48	0.498[ns]
	S.E.	b0.31	0.31	0.31	

[a] Mean of 29 acceptability values.

[b] Any two means not underscored by the same line are significantly different at the ($P<.01$) level.

** Highly Significant ($P<.01$)

ns Non-significant ($P<.05$)

has reported that food in the intermediate moisture ranges are more susceptible to this reaction than are dry foods. Also the high acid environment of the intermediate moisture sauce has probably hydrolyzed the sugars and proteins present, thus giving rise to darkening of the meat.

Highly significant differences ($P<.01$) in the acceptability values were also found for pork with sweet and sour sauce. Significant differences in acceptability ($P<.01$) were found to lie between the zero ($\bar{X} = 6.38$) and three month ($\bar{X} = 4.93$) storage periods, and the zero and six month period ($\bar{X} = 5.14$). No significant difference ($P<.05$) was noted between the three and six month periods. This data indicates that the intermediate moisture pork with sweet and sour sauce will not tolerate temperatures of 38°C. for long periods of time if palatability of the product is to be maintained. Again, meat browning due to the Maillard Reaction and high acid environment of the sauce are probably the main reason for loss of product palatability.

No significant differences ($P<.05$) were found between acceptability means of pork with oriental sauce at the zero, three and six month storage periods. Although no significant differences were noted in acceptability, the pork chunks did exhibit a noticeably darker color at six months as compared with the three month period (note gross examination discussion).

Acceptability values for intermediate moisture ham with sweet mustard sauce were also found to be non-significant ($P<.05$) for the three storage periods tested. Data gathered on intermediate moisture pork with oriental sauce and ham with sweet mustard sauce indicated that these items maintain their sensory characteristics over relatively long periods of time at elevated temperatures.

SUMMARY

Four intermediate moisture meat entree items developed at the U.S. Army Natick Laboratories, Natick, Massachusetts, were held in storage for a period of six months at 38°C. The products studied were intermediate moisture pork with barbecue sauce, pork with sweet and sour sauce, pork with oriental sauce, and ham with sweet mustard sauce.

Microbiological, nutritional, and sensory evaluations were conducted on these products at pre-determined storage intervals.

The meat portion of each product was prepared by the "cook-soak-equilibration" method in an aqueous glycerol-salt-antimycotic solution. Intermediate moisture sauces were formulated by combining conventional sauce ingredients with pre-determined amounts of glycerol to give a completed sauce with the desired water activity (A_w = 0.80-0.85). Finished products were vacuum sealed in flex-paks and stored at 38°C. for six months.

Upon gross examination, only slight differences in color and appearance could be detected between the zero and three month storage periods. However, six month samples exhibited a marked darkening of the meats.

Taste panel evaluation indicated that pork with barbecue sauce maintained its sensory properties for at least three months in storage at 38°C. A significant decrease in palatability was noted for pork with sweet and sour sauce between the zero and three month storage periods, while no significant difference ($P<.05$) could be detected in panel acceptability values for pork with oriental sauce and ham with sweet mustard sauce throughout the six month storage period at 38°C.

Nutritional data indicated that intermediate foods are comparable in nutrient content to existing combat ration meat components, and that vitamin retention during storage is similar to those foods processed by commercial methods.

Microbiological data indicated that all products tested were microbially stable under non-sterile conditions, and required no commercial sterilization.

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13. ABSTRACT

Four intermediate moisture meat entree items (A_w 0.81 - 0.86) developed at the U.S. Army Natick Laboratories, Natick, Massachusetts, were held in storage for a period of six months at 38°C. The products studied were, intermediate moisture pork with barbecue sauce, pork with sweet and sour sauce, pork with oriental sauce, and ham with sweet mustard sauce.

Microbiological, nutritional, and sensory evaluations were conducted on these products at pre-determined storage intervals.

Taste panel evaluation indicated that pork with barbecue maintained its sensory properties for three months at 38°C., without any significant change, while ham with sweet mustard sauce and pork with oriental sauce had no loss in panel acceptability over the six month period. Pork with sweet and sour sauce showed a significant decrease in panel acceptability between the zero and three month storage periods.

Vitamin and chemical data indicate that these intermediate moisture foods are comparable to existing combat ration meat components in nutrient content, and that vitamin retention during storage is similar to those of foods processed by commercial methods.

Microbiological data indicated that all products tested with microbially stable.

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